

MULTIMEDIA



UNIVERSITY

STUDENT ID NO

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MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 2, 2015/2016

EEE 7276 – DESIGN OF ON AND OFF GRID PV SYSTEMS

10 MARCH 2016
2:30 pm – 5:30 pm
(3 Hours)

INSTRUCTIONS TO STUDENTS

1. This Question paper consists of 4 pages including the cover page with 5 Questions only.
2. Answer ALL questions. The distributions of marks for each question are as stated.
3. Please print all your answers in the Answer Booklet provided.

Question 1

- (a) What are the two common coordinates used to specify the position of the sun, if one assumes the earth orbit is circular around the sun? Explain them. [6 marks]
- (b) Calculate the sunrise time at a place whose latitude is 40° N and longitude is 110° W on July 1. The time zone of the place is based on 120° W. Neglect correction due to Equation of Time (EoT). (Hint: $\cos\omega_s = -\tan\delta \cdot \tan\phi$). [7 marks]
- (b) The sun's position in the sky at 9:00 AM on December 21 at a place where the latitude is 30° N is given by altitude, $\alpha = 21.27^\circ$ and azimuth, $\psi = 44.12^\circ$ east of south. Determine the tilt angle of rows of solar arrays of length = 2 m to capture the maximum sun irradiation. Also compute the minimum inter row spacing between the arrays to avoid shade during the time period of 6 hours from 9:00 AM. [7 marks]

Question 2

- (a) Derive an expression for the voltage at maximum power point for a particular irradiance of a solar PV assuming ideal cell model. [6 marks]
- (b) Two mismatched PV modules are connected in parallel. The I-V characteristic of each module is shown in Fig. Q2. Sketch the I-V characteristic of the combined module and compute the maximum power that could be delivered. [8 marks]

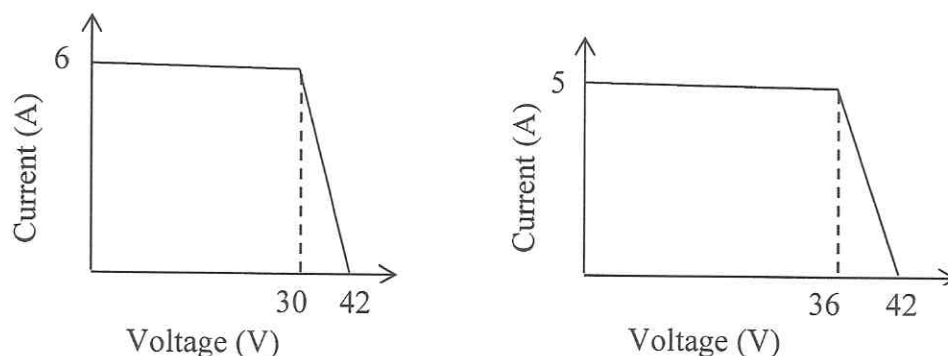


Fig. Q2

- (c) A 36-cell PV module had a parallel resistance per cell of $R_p = 6.6 \Omega$. In full sun and at $I = 2.14$ A the output voltage is found to be 19.41 V. One cell in the module is shaded and the output current remains unchanged.
- What would be the shaded module voltage and power? [4 marks]
 - Compute the voltage drop across the shaded cell? [1 mark]
 - How much power would be dissipated in the shaded cell? [1 mark]

Continued...

Question 3

- (a) Briefly explain the different components of solar radiation on a solar collector. [8 marks]
- (b) A grid-connected PV array consists of sixteen modules. Their specifications under standard test conditions are given in Table 1. They can be arranged in a number of series and parallel combinations. The array delivers power to the grid through a maximum power point tracker (MPPT) and an inverter. The specifications of MPPT are given in Table 2. Design a suitable combination of the modules for this grid connected system.

Table 1: Characteristics of PV module under STC

Rated Power	150W
Voltage at max power	34 V
Current at max power	4.40 A
Open Circuit Voltage	43.4 V
Short Circuit Current	4.8 A

Table 2: Characteristics of MPPT

PV Voltage range at max power	250-500 V
Maximum input voltage of MPPT	600V

[6 marks]

- (c) Design a suitable combiner box configuration for a 250-kW PV system using 8-module source circuit. The ratings of the PV module and the inverter are given below. The maximum current of a combiner box is 192 A. Output AC voltage can vary from 208 V to 277 V. Assume the inverter efficiency = 96%.

Ratings of a PV module:

Power rating = 305 W_p $V_{OC} = 64.2$; $I_{SC} = 5.96$ A; $V_{MP} = 54.7$ V $I_{MP} = 5.58$ A

Inverter rating:

 $V_{OC, max} = 600$ V; 250 V < $V_{MP} < 480$ V; $I_{inverter, max} = 30$ A;

[6 marks]

Continued...

Question 4

- (a) Explain the main differences between the design of Grid-connected PV system and Stand-alone PV system. [6 marks]

- (b) Design a stand-alone PV system to supply a residence with AC loads = 1200 Wh and DC loads = 200 Wh. The system employs a 24 V battery with efficiency = 85%. The inverter used in the system has the output voltage rating of 240 VAC. The efficiency of the inverter is 90%. The solar irradiation at the place = 4.5 kWh/m² per day. The PV panel used has the following ratings:

Rated Power 80Wp; Tolerance $\pm 5\%$; Nominal Voltage 12V

The design result should have the number of PV panels required, PV configuration, and battery and inverter sizes. Assume 90% power loss in the cabling. Assume 5 days of autonomy for battery selection and DOD = 80%. [10 marks]

- (c) State the functions of charge controllers in Stand-alone PV system. [4 marks]

Question 5

- (a) Explain the mechanical issues that affect the electrical performance of the PV arrays. [4 marks]

- (b) What are the types of PV-array mounting system commonly employed. [6 Marks]

- (c) The total PV installation cost including all the incentive is RM 35,000. The number of PV Panels is 25 and the STC rating of a panel is 180 Wp. Assume actual energy generation is 80% of ideal PV generation. PSH at that location is 4.5 and the electricity rate is RM 0.40 per kWh. Calculate the payback period assuming the annual electricity rate of inflation is 4%. [10 marks]

End of Paper